Do Older Skiers Have Worse Outcomes After Anterior Cruciate Ligament Reconstruction Compared With Non-Skiers or Younger Skiers?

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Background: There remains a paucity of literature comparing clinical outcomes after anterior cruciate ligament reconstruction (ACLR) between skiers and non-skiers, particularly in older patient populations.

Purpose: To compare clinical outcomes after ACLR between skiers and non-skiers, with a subanalysis based on age.

Study Design: Cohort study; Level of evidence, 3.

Methods: A nested cohort of 128 patients from the Multicenter Orthopaedic Outcomes Network cohort who underwent primary ACLR completed a series of patient-reported outcomes pre- and postoperatively at 2 and 6 years including the Knee injury and Osteoarthritis Outcome Score (KOOS), Marx Activity Rating Scale, and subjective International Knee Documentation Committee (IKDC) score. Data including patient sex, age at surgery, graft type, and sport participation were analyzed. Patients were stratified by participation in skiing (skiers vs non-skiers) and by age subgroup ($\leq$29, 30-39, and $\geq$40 years). Student *t* tests and analysis of variance were used to compare mean improvement between pre- and postoperative outcomes.

Results: A total of 44 skiers (female, 59.1%; age, 35.3 $\pm$ 11.6 years) and 84 non-skiers (female, 34.5%; age, 27.7 $\pm$ 11.3 years) were included. ACLR was performed using allograft in 36.7% (22 skiers, 25 non-skiers), autograft in 58.6% (19 skiers, 56 non-skiers), or hybrid autograft-allograft in 4.7% (3 skiers, 3 non-skiers). Although both non-skiers and skiers demonstrated improvements in outcomes from baseline to 2 and 6 years, non-skiers demonstrated significantly less overall improvement from 2 to 6 years postoperatively in KOOS Symptoms ($P = .01$), KOOS Pain ($P = .002$), and KOOS Activities of Daily Living ($P = .03$) subscales compared with skiers. There were 15 skiers who were 29 years or younger (34.1%), 14 skiers between 30 and 39 years (31.8%), and 15 skiers 40 years or older (34.1%). Skiers 40 years and older demonstrated significantly greater mean improvement in KOOS Symptoms ($P = .02$) and KOOS Quality of Life (QoL) ($P = .01$) subscales at 2 years and KOOS QoL ($P = .01$) at 6 years postoperatively compared with skiers 29 years or younger.

Conclusion: Compared with non-skiers, skiers demonstrated significantly greater mean improvements in KOOS scores between 2 and 6 years after ACLR. In addition, skiers 40 years or older showed greater improvement in KOOS QoL compared with younger skiers. This information can be used to counsel skiers, especially those older than 40 years, as to their expected outcomes after ACLR.

Keywords: anterior cruciate ligament reconstruction; skiing; patient outcomes; patient education

Anterior cruciate ligament (ACL) injuries are common in athletic populations, particularly in athletes participating in high-risk cutting and pivoting sports and activities, such as skiing.[3,8,12,26,30] Previous studies have evaluated the risks and outcomes of skiing after ACL injuries with[10,13,16,28] or without reconstruction.[16,24] However, the majority of studies reporting outcomes after ACL reconstruction (ACLR) have included patients who are young and/or who are elite athletes.[10,13,22] A recent study by Nwachukwu et al[23] investigated differences among sport types for patient-reported outcomes (PROs) after ACLR. In that study, the investigators demonstrated that competitive skiers had significantly lower baseline International Knee Documentation Committee (IKDC) scores ($P = .08$) and

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Lysholm scores ($P = .03$) compared with other sports; however, the investigators did not include a subgroup analysis of the PROs by patient age.

To date, there remains a paucity of literature comparing clinical outcomes after ACLR between recreational skiers and non-skiers, particularly in older patient populations. Because preoperative expectations have been shown to influence a patient's assessment of outcomes, satisfaction,[11] and overall success of the procedure,[5,14,20] this information could be a valuable tool for clinicians so they can counsel skiers, especially older skiers, as to their expected clinical outcomes after ACLR. The purpose of this study was to compare outcomes after ACLR between skiers and non-skiers, with a subgroup analysis based on patient age. We hypothesized that (1) skiers would demonstrate improved outcomes over time after ACLR compared with non-skiers and that (2) older skiers would have similar outcomes to younger skiers.

METHODS

Study Design and Setting

A retrospective nested cohort analysis was performed using prospectively collected data from the Multicenter Orthopaedic Outcomes Network (MOON) Knee Group for patients undergoing primary ACLR. The data collection methods by this group have been previously reported.[9]

Participants

Institutional review board approval was obtained at participating institutions. Patients undergoing unilateral primary ACLR between January 1, 2002, and December 31, 2008, were included. These dates were chosen because the MOON ACL protocol subsequently changed to limit enrollment to only young athletes. Starting in 2009, only the highest enrolling MOON sites continued to enroll, and the inclusion criteria changed in order to fulfill a National Institutes of Health grant aim to look at progression of osteoarthritis in young athletes. For the purposes of this study, participants undergoing revision ACLR, bilateral ACLR, or concomitant medial or lateral collateral ligament reconstruction were excluded. Participants were eligible for enrollment in the University of Colorado's nested cohort if they had undergone ACLR by 1 of 3 sports medicine fellowship trained orthopaedic surgeons (E.C.M., A.F.V., M.L.W.). Participants were excluded if they had exclusively preoperative data and no postoperative follow-up at either 2 or 6 years after primary ACLR.

Variables

Patients were stratified by sport participation (skiers vs non-skiers), and skiers were further stratified into age groups: $\leq$29 (younger), 30-39 (middle), $\geq$40 (older) years of age. Patients were considered skiers if they answered "skiing" as 1 of 2 sports in which they had participated over the past 2 years based on a preoperative demographic questionnaire. Non-skiers did not list skiing as 1 of 2 sports in which they were active. Patients also recorded their level of sport participation: recreational, high school, college, amateur, or professional. Variables extracted from each patient included patient characteristics and a series of PRO scores. Patient characteristics included patient age at the time of surgery, sex, graft type (autograft, allograft, or a hybrid autograft-allograft), and sport participation. PRO scores included the Knee injury and Osteoarthritis Outcome Score (KOOS) including the following KOOS subdomains: KOOS Symptoms, KOOS Pain, KOOS Quality of Life (QoL), KOOS Activities of Daily Living (ADL), and KOOS Sport;[27] the Marx Activity Rating Scale (Marx);[21] and subjective IKDC score.[15] PRO scores were collected preoperatively and postoperatively at 2 and 6 years after primary ACLR.

Statistical Analysis

A repeated-measures 1-way analysis of variance was used to compare preoperative and postoperative outcome measures of skiers and of non-skiers. Student t tests were used to compare the mean improvement from preoperative to postoperative outcome scores between skiers and non-skiers, while a 1-way analysis of variance was used to compare the mean improvement between preoperative and postoperative outcome measures within the different age stratifications of skiers. Tukey post hoc analysis was used in cases in which $P < .05$. For categorical variables, a chi-square test was performed. A P value of $< .05$ was considered statistically significant for all analyses. All statistical analyses were

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TABLE 1
Patient Characteristics by Participation in Skiing

Characteristic	Skiers	Non-Skiers	Total
Patients, n (%)	44 (34.4)	84 (65.6)	128 (100)
Female sex, n (%)	26 (59.1)	29 (34.5)	55 (43.0)
Patient age,[a] y	35.3 ± 11.6	27.7 ± 11.3	30.3 ± 11.9
Graft type, n (%)			
Allograft	22 (50.0)	25 (30.0)	47 (36.7)
Autograft	19 (43.2)	56 (66.7)	75 (58.6)
Hybrid graft	3 (6.8)	3 (3.6)	6 (4.7)

[a]Patient age at the time of surgery, expressed as mean ± SD.

TABLE 2
Skier Characteristics by Age Subgroup

Characteristic	Skiers ≤29y	Skiers 30-39y	Skiers ≥40y
Patients, n (%)	15 (34.1)	14 (31.8)	15 (34.1)
Female sex, n (%)	11 (73.3)	7 (50.0)	8 (53.3)
Patient age,[a] y	23.4 ± 3.5	34.1 ± 2.5	48.4 ± 7.6
Graft type, n (%)			
Allograft	5 (33.3)	8 (57.1)	9 (60.0)
Autograft	10 (66.7)	4 (28.6)	5 (33.3)
Hybrid graft	0 (0.0)	2 (14.3)	1 (6.7)

[a]Patient age at the time of surgery, expressed as mean ± SD.

conducted using the Statistical Package for the Social Sciences software package (Version 25; SPSS Inc).

RESULTS

Patient Demographics

The study included 44 skiers (59% female; age, 35.3 ± 11.6 years) and 84 non-skiers (35% female, $P = .008$; age, 27.7 ± 11.3 years, $P = .006$) (Table 1). A significant difference was seen between ACL graft type and participation in skiing ($P = .04$), with a high percentage of autografts being used in the non-skiers (66.7%) and similar percentages of autografts (43.2%) and allografts (50.0%) being used in the skiers. Primary ACLR was most commonly performed with an autograft (58.6%). Within the non-skier group, primary sports included soccer (15.5%), basketball (14.3%), football (14.3%), baseball/softball (2.4%), gymnastics (1.2%), "other" (51.2%), or none (1.2%). Sport level included recreational, high school, college, amateur, and professional. There were 41 skiers who classified themselves as recreational skiers (93.2%), whereas 3 skiers had previous competitive experience (6.8%). Of the 128 participants, 124 participants completed 2-year follow-up (96.9%), and 113 participants completed 6-year follow-up (88.3%). All participants completed preoperative and at least 1 postoperative follow-up assessment in order to be included.

When stratified by age groups, there were 15 younger skiers (34%), 14 skiers in the middle group (32%), and 15 older skiers (34%) (Table 2). In younger skiers, 5 (33.3%) had an allograft, and 10 (66.7%) had an autograft. In the middle age group of skiers, 8 (57.1%) had an allograft, 4 (28.6%) had an autograft, and 2 (14.3%) had a hybrid graft. In older skiers, 9 (60.0%) had an allograft, 5 (33.3%) had an autograft, and 1 (6.7%) had a hybrid graft. No significant differences were found among the age groups of skiers with respect to graft type ($P = .32$) or sex ($P = .39$).

Patient-Reported Outcomes

Skiers Versus Non-Skiers. All skiers and non-skiers significantly improved in all the KOOS subdomains and subjective IKDC scores between baseline and 6 years postoperatively ($P < .05$). Skiers had significantly greater improvement in KOOS Pain (88.3 ± 14.5 to 94.1 ± 9.9; $P = .03$) and KOOS QoL (70.6 ± 21.0 to 79.0 ± 20.5; $P = .04$) from 2 to 6 years postoperatively compared with the non-skiers (91.6 ± 9.1 to 89.6 ± 12.6 and 70.1 ± 21.1 to 71.9 ± 21.9, respectively; $P > .05$). At 6 years after ACLR, skiers had significantly higher scores in KOOS Symptoms (91.4 ± 9.2), KOOS Pain (94.1 ± 9.9), and KOOS Sport (88.7 ± 14.4) compared with non-skiers (84.2 ± 14.1, $P = .001$; 89.6 ± 12.6, $P = .04$; 81.4 ± 20.1, $P = .03$, respectively) (Figure 1). The mean Marx scores from baseline to 6 years decreased in both skiers (8.5 ± 4.5 to 6.3 ± 4.4) and non-skiers (12.0 ± 4.3 to 8.4 ± 4.9). Skiers reported a significantly lower Marx score than non-skiers at baseline (8.5 ± 4.5 vs 12.0 ± 4.3; $P < .001$), 2 years (6.2 ± 4.4 vs 9.1 ± 4.8; $P = .001$), and 6 years (6.3 ± 4.4 vs 8.4 ± 4.9; $P = .02$) (Figure 1).

Skiers demonstrated significantly greater mean improvement from baseline to 6 years in KOOS Symptoms (26.0 ± 18.3) compared with non-skiers (17.4 ± 25) ($P = .04$) (Appendix Table A1). Non-skiers demonstrated significantly less overall mean improvement in KOOS Symptoms, KOOS Pain, and KOOS ADL (–2.1 ± 12.5; –2.5 ± 11.6; –1.0 ± 6.0, respectively) from 2 to 6 years postoperatively compared with skiers (3.4 ± 9.9, $P = .01$; 4.2 ± 9.9, $P = .002$; 1.9 ± 6.8, $P = .03$, respectively). No significant differences were found between groups in mean improvement at 2 years in any outcome measure ($P > .05$ for all) or at 6 years in the Marx ($P = .23$), KOOS QoL ($P = .67$), KOOS Sport ($P = .05$), and IKDC ($P = .24$) (Appendix Table A1).

Age Subgroups of Skiers. Skiers in all age groups demonstrated significant improvements from baseline to 6 years on all KOOS subdomains ($P < .05$) and the IKDC ($P < .001$). Younger skiers significantly declined on the Marx from baseline to 6 years (10.1 ± 4.8 to 7.0 ± 5.0; $P = .001$) compared with skiers in the middle age group (9.9 ± 3.1 to 6.8 ± 4.4; $P = .11$) and older skiers (5.7 ± 4.1 to 5.1 ± 3.9; $P = .78$) (Figure 2). In KOOS Symptoms, middle-aged skiers had significantly lower 2-year scores (82.4 ± 11.2) compared with older skiers (94.3 ± 5.7; $P = .001$), and middle-aged skiers had significantly lower 6-year scores (84.8 ± 11.2) compared with younger skiers (93.6 ± 7.8; $P = .03$) and older skiers (94.5 ± 5.9; $P = .01$) (Figure 2). Younger skiers and older skiers did not differ significantly in their KOOS Symptoms scores at any timepoint ($P > .05$). Older skiers had significantly lower baseline Marx scores compared with younger skiers ($P = .01$) and skiers aged 30 to 39 years ($P = .01$).

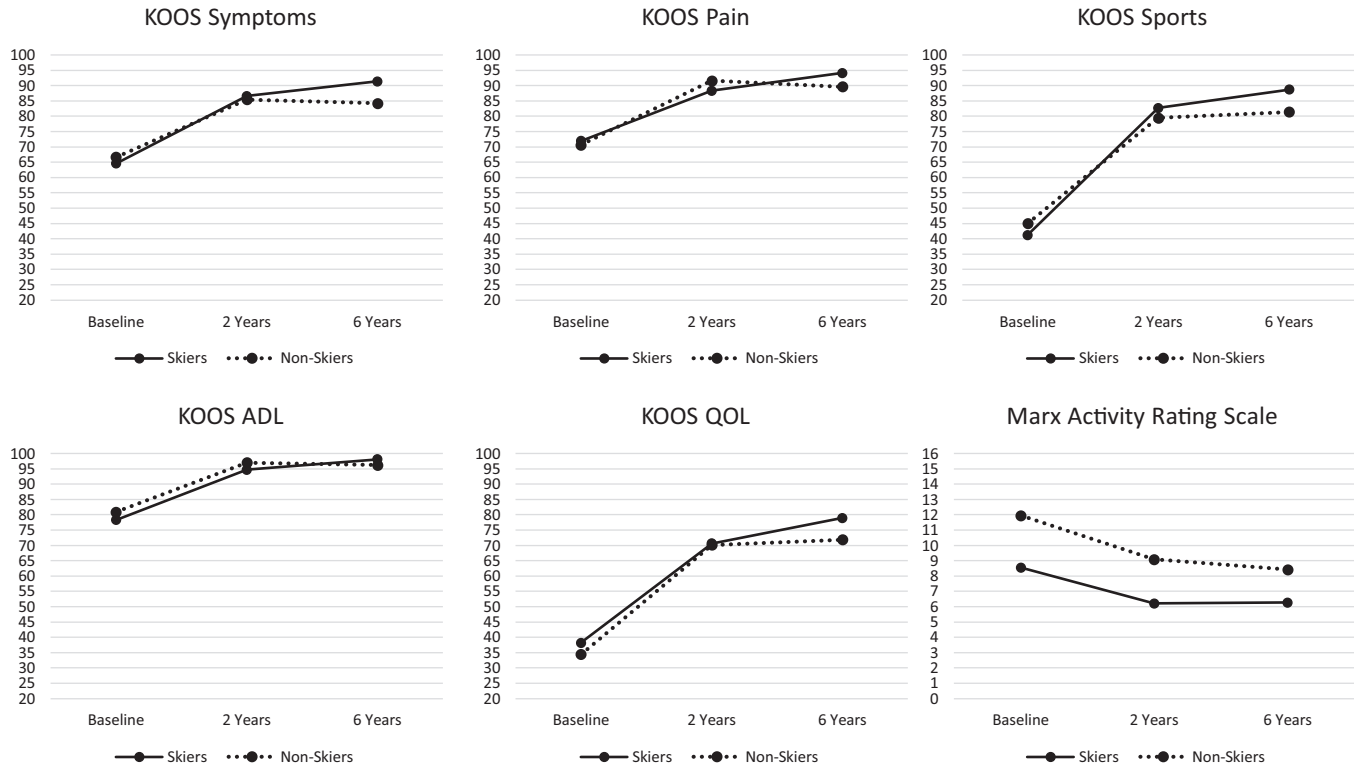

Figure 1. Knee injury and Osteoarthritis Outcome Score (KOOS) and Marx Activity Rating Scale scores of skiers and non-skiers. ADL, Activities of Daily Living; QOL, Quality of Life.

Older skiers demonstrated a significantly greater mean improvement in KOOS Symptoms (32.6 ± 20.6) and KOOS QoL (46.3 ± 26.1) from baseline to 2 years postoperatively compared with younger skiers (15.5 ± 18.9, $P = .02$; 18.8 ± 24.0, $P = .01$, respectively) (Appendix Table A2). Older skiers also demonstrated a significantly greater mean improvement at 6 years in KOOS QoL (52.9 ± 18.3) compared with younger skiers (26.8 ± 25.4; $P = .01$). Between 2 and 6 years postoperatively, no significant differences were observed in skiers based on age in the KOOS, Marx, or IKDC outcome measures ($P > .05$ for all).

DISCUSSION

The principle findings of this study are that (1) compared with non-skiers, skiers demonstrated significantly greater mean improvements in KOOS scores between 2 and 6 years after ACLR, and (2) skiers who were 40 years or older at the time of surgery had significantly greater improvement in KOOS QoL scores at 2 and 6 years after primary ACLR when compared with skiers who were 29 years or younger at the time of surgery.

Although several studies exist on the high incidence of ACL tears in skiing (incidence range, 7.1%-27.7%)[12,18,24-26,28] and return to skiing after ACLR (return rate, 40%-80%),[10,13,16,22] few studies have focused on comparing PROs after primary ACLR between skiers and non-skiers. One study by Nwachukwu et al[23] compared PROs between skiers (n = 67) and participants in other sports including soccer, basketball, lacrosse, football, and tennis (n = 227). That study found that skiers had significantly lower baseline outcome scores on the IKDC and Lysholm ($P < .05$) and trended toward lower outcome scores on the Tegner and Marx ($P = .05$) compared with those who participated in other sports.[23] In the present study, there were no significant differences in outcomes at baseline between skiers and non-skiers ($P > .05$) for KOOS and IKDC. However, non-skiers demonstrated significantly higher baseline Marx scores ($P < .001$) compared with skiers of all ages. Compared with the study by Nwachukwu et al where patients were followed up for only 2 years, the present study followed patients for 6 years. Although PROs were comparable at 2 years in our study (except for Marx, $P = .001$), skiers had significantly higher scores for subscales KOOS Symptoms ($P = .001$), KOOS Pain ($P = .04$), and KOOS Sports ($P = .03$) compared with non-skiers at 6 years postoperatively. It has been previously demonstrated that female sex is associated with a lower activity level and higher baseline activity levels are associated with higher activity at 2 years after ACLR.[9] Thus, the results of our study may explained by the fact that the recreational skiers tended to be older and female and had undergone ACLR with an allograft, whereas the non-skiers tended to be younger and male, were more active at baseline, and had undergone ACLR with an autograft. Although the Marx scores decreased for both

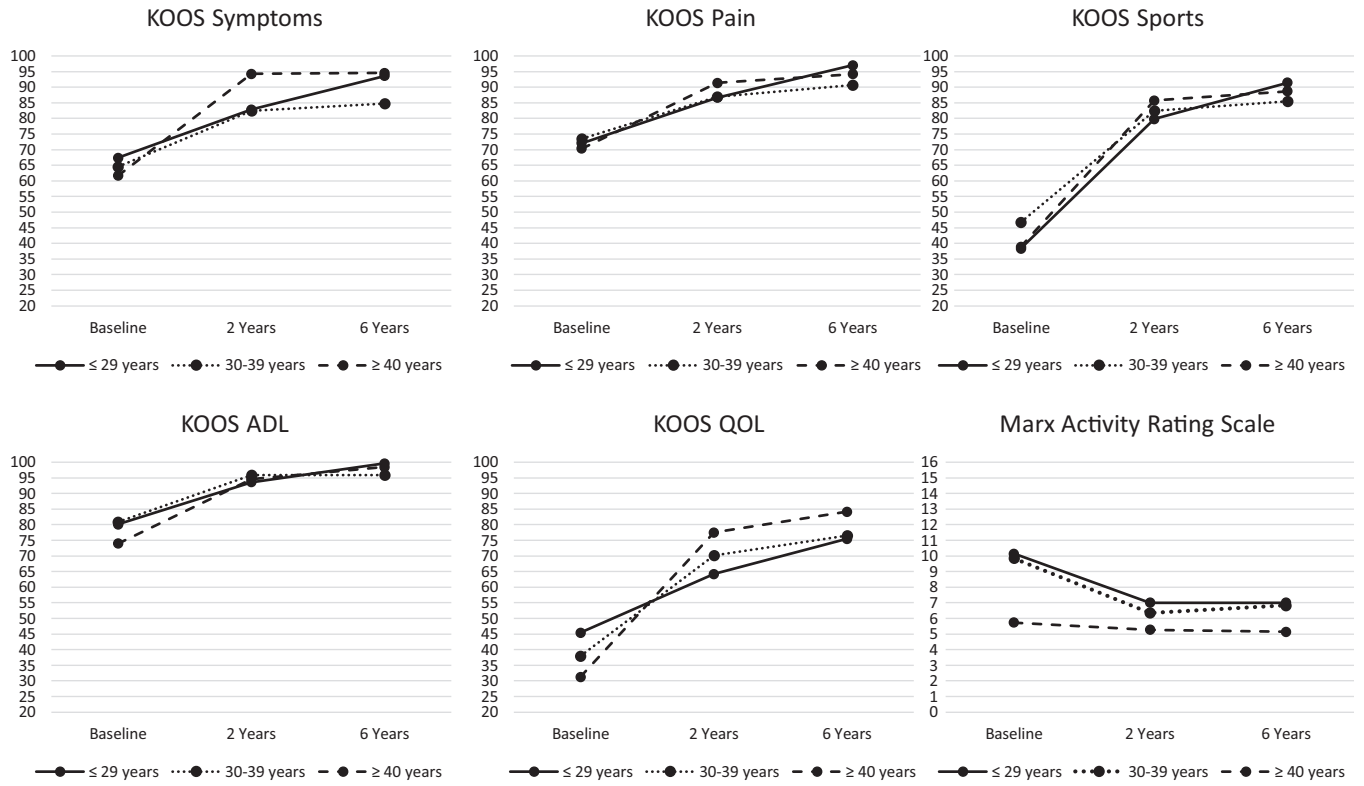

Figure 2. Knee injury and Osteoarthritis Outcome Score (KOOS) and Marx Activity Rating Scale scores of younger, middle-aged, and older skiers. ADL, Activities of Daily Living; QOL, Quality of Life.

skiers and non-skiers over time, skiers demonstrated a significantly greater decrease in the Marx score at 6 years compared with non-skiers ($P = .02$). According to Antosh et al,[1] who studied primary ACLR and change in outcomes in a younger athletic population (average age, 19 years), decreases in activity level on the Marx occur over time and may not necessarily reflect poorer PRO scores. The Marx[21] measures very specific activity, such as cutting and pivoting, and a decrease in score is likely due to general aging and patients having fewer opportunities to engage in these types of activities on the Marx.[1]

One important difference in our study design was that we compared the mean improvement of outcome scores over time between skiers and non-skiers. Skiers and non-skiers often improve over time in most PRO scores, so it was important to quantify how much each group actually improved compared with one another. A significantly greater difference in mean improvement was found between skiers and non-skiers from 2 years to 6 years after ACLR in the KOOS Symptoms, KOOS Pain, and KOOS ADL ($P < .05$). Skiers improved in these subscales on average by +3.2 points between 2 and 6 years, whereas non-skiers declined on average by –1.9 points between 2 and 6 years. However, by 6 years after primary ACLR, the only significantly greater difference that we found entailed improvement in skiers' KOOS Pain score ($P = .04$) compared with non-skiers, while all other PRO scores were comparable ($P > .05$). Skiers and non-skiers can expect similar outcomes over a longer period of time after primary ACLR with any type of graft. However, skiers tend to have a more linear recovery than non-skiers potentially due to patient expectations and working toward returning to their recreational sport. Moreover, although younger age and male sex have been shown to influence the level of a patient's return to sports activity after primary ACLR,[2,4,7,14] the high proportion of females and older age of the skiers did not appear to influence the results. This may be explained by differences in the amount of structured time these patients dedicate to their recovery.[14]

The increase in ACLRs during the past decade in patients older than 40 years[17,19,31] makes focusing on patient outcomes in this population a priority for practicing orthopaedic surgeons. In a recent meta-analysis by Kim et al,[17] clinical outcomes in patients older than 40 years who underwent ACLR were not significantly different than clinical outcomes in those younger than 40, indicating that the prognosis of ACLR is not dependent on patient age. With ACL injuries being a common occurrence in competitive and recreational skiers, it can be presumed that many older patients sustain ACL injuries from skiing and wish to return to this desired activity after surgical reconstruction of their ACL as well as to a generally active lifestyle. Our study did not document how the ACL injury occurred, but Desai et al[6] investigated the outcomes of 1990 patients older than 40 years who underwent primary ACLR between 2005 and 2012; the investigators found that 28.8% of ACL

injuries in patients older than 40 years were due to alpine skiing compared with 11.4% in patients aged 20 to 29 years of age and 16.7% in patients aged 30 to 39 years.[6]

The present study compared the outcomes of 3 age groups of skiers (younger, middle, and older) after primary ACLR. The most significant finding was that older skiers had significantly greater improvement in KOOS QoL at 2 and 6 years after ACLR when compared with younger skiers ($P = .01$). This could be due to several reasons including but not limited to the following: Due to beginning with a lower preoperative KOOS QoL score compared with younger skiers[6] and younger or middle-aged skiers, older skiers may believe that their recovery is lengthy and may be eager to return to sport at their preinjury level. Similar reasons could describe why the improvement in KOOS Symptoms score was significantly greater at 2 years in older skiers. Interestingly, the skiers in the middle-aged group reported a significantly lower KOOS Symptoms score than older skiers at 2 years postoperatively. The middle-aged skiers also reported significantly lower KOOS Symptoms scores than younger and older skiers at 6 years postoperatively ($P < .05$). It is possible that older skiers may have had more improvement in symptoms as a result of having realistic expectations of recovery[5,11,20] due to their increased age, while middle-aged skiers had yet to accept that it is a possibility that they may not return to their preinjury activity level. In a recent case series examining patients older than 60 years after ACLR, 50% returned to their preinjury sport level,[29] while a meta-analysis demonstrated that only 65% of patients return to preinjury sport level in all ages (average age, 25.8 years).[2] Moreover, the baseline Marx score was significantly lower in older skiers compared with middle-aged and younger skiers, most likely reflecting the specific Marx questions asked. No significant difference was found between timepoints in older skiers on the Marx, showing that as patients age it is common to have a lower activity score. All other PROs were not significantly different among skiers of all ages, which demonstrates that older skiers can expect similar outcomes at 2 and 6 years after ACLR compared with younger skiers. Additionally, graft type was found to not be a significant factor among the age groups of skiers ($P = .32$).

Limitations

Although the study had several notable strengths including the follow-up duration of 6 years and the prospective nature of the data collection, there were several limitations to this study. The limitations include the heterogeneity of different surgeons performing the ACLR, the heterogeneity of populations compared, only comparing non-skiers to skiers with no further sport breakdown, no return to sports follow-up, no further breakdown on concomitant injuries, and small sample sizes for the age stratification analysis. Additionally, the small sample sizes for the age subgroups of the skiers limited the ability to further stratify by graft types. Moreover, there are limitations with using subjective PRO scores when comparing skiers versus non-skiers. In this comparison, there may be bias associated with the questions included in the Marx due to only 1 of the 4 questions being specific to the skiing population. Finally, the definition of a recreational skier is vague due to skiing being a seasonal sport. Therefore, it was not possible to assess (1) in what activities the skiers were participating during the off-season, (2) the frequency of skiing per year, and (3) the intensity of skiing (ie, different types of skiing terrain). Future studies should focus on larger sample sizes as well as comparing skiers to a nonathletic population group.

CONCLUSION

Compared with non-skiers, skiers demonstrated significantly greater mean improvements in KOOS scores between 2 and 6 years after ACLR. In addition, skiers 40 years or older showed greater improvement in KOOS QoL compared with younger skiers. This information can be used to counsel skiers, especially those older than 40 years, as to their expected outcomes after ACLR.

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APPENDIX

TABLE A1
Improvement in Patient-Reported Outcomes Between Skiers and Non-Skiers[a]

	Preoperative to 2 Years Postoperative					2 Years to 6 Years Postoperative					Preoperative to 6 Years Postoperative				
	Skiers		Non-Skiers			Skiers		Non-Skiers			Skiers		Non-Skiers		
PROs	n	Score	n	Score	*P*	n	Score	n	Score	*P*	n	Score	n	Score	*P*
KOOS Symptoms	44	22.1 ± 18.9	80	19.7 ± 19.9	.51	41	3.4 ± 9.9	72	–2.1 ± 12.5	.01[b]	41	26.0 ± 18.3	76	17.4 ± 25.2	.04[b]
KOOS Pain	44	16.4 ± 16.8	80	21.6 ± 17.7	.11	41	4.2 ± 9.9	72	–2.5 ± 11.6	.002[b]	41	21.2 ± 15.1	76	18.8 ± 22.0	.50
KOOS ADL	44	16.4 ± 16.0	79	16.0 ± 15.9	.89	41	1.9 ± 6.8	71	–1.0 ± 6.0	.03[b]	41	19.1 ± 16.5	76	15.5 ± 16.9	.26
KOOS Sport	43	41.5 ± 28.2	78	34.2 ± 29.8	.19	40	4.9 ± 15.0	71	1.0 ± 19.3	.23	39	48.7 ± 25.2	75	36.3 ± 34.6	.05
KOOS QoL	44	32.4 ± 25.0	80	36.0 ± 24.5	.44	41	7.3 ± 17.8	72	2.3 ± 16.7	.15	41	39.8 ± 24.8	76	37.7 ± 27.6	.67
Marx	44	–2.3 ± 5.3	79	–2.9 ± 4.4	.53	41	0.1 ± 4.0	71	–0.4 ± 4.5	.50	41	–2.5 ± 4.1	71	–3.5 ± 5.0	.23
IKDC	44	30.9 ± 20.2	80	31.6 ± 17.4	.83	41	4.9 ± 15.0	71	0.3 ± 11.8	.10	41	36.4 ± 16.0	75	32.3 ± 21.0	.24

[a]Scores are presented as mean ± SD. ADL, Activities of Daily Living; IKDC, International Knee Documentation Committee score; KOOS, Knee injury and Osteoarthritis Outcome Score; Marx, Marx Activity Rating Scale; PRO, patient-reported outcome; QoL, Quality of Life.
[b]$P < .05$.

TABLE A2
Improvement in Patient-Reported Outcomes Among Skiers of Different Ages[a]

	Preoperative to 2 Years Postoperative							2 Years to 6 Years Postoperative							Preoperative to 6 Years Postoperative						
	Skiers ≤29y		Skiers 30-39y		Skiers ≥40y			Skiers ≤29y		Skiers 30-39y		Skiers ≥40y			Skiers ≤29y		Skiers 30-39y		Skiers ≥40y		
PROs	n	Score	n	Score	n	Score	*P*	n	Score	n	Score	n	Score	*P*	n	Score	n	Score	n	Score	*P*
KOOS Symptoms	15	15.5 ± 18.9[b]	14	17.9 ± 11.8	15	32.6 ± 20.6[b]	.02[b]	14	5.9 ± 10.9	12	4.5 ± 10.3	15	0.2 ± 8.5	.29	14	22.7 ± 20.6	12	21.1 ± 10.0	15	32.9 ± 20.0	.18
KOOS Pain	15	14.6 ± 15.8	14	13.5 ± 13.9	15	21.0 ± 20.0	.43	14	5.6 ± 9.2	12	4.3 ± 13.0	15	2.8 ± 8.3	.77	14	22.0 ± 16.0	12	16.8 ± 11.7	15	23.8 ± 16.8	.48
KOOS ADL	15	13.5 ± 15.8	14	15.0 ± 13.8	15	20.7 ± 18.1	.44	14	0.9 ± 1.6	12	0.6 ± 6.8	15	3.8 ± 9.2	.37	14	16.7 ± 14.0	12	15.1 ± 16.9	15	24.5 ± 18.0	.28
KOOS Sport	15	41.5 ± 23.9	14	35.7 ± 28.9	14	47.2 ± 32.3	.57	14	6.6 ± 14.7	12	4.6 ± 18.6	14	3.6 ± 12.8	.87	14	52.1 ± 20.5	12	36.3 ± 26.8	13	53.7 ± 26.5	.16
KOOS QoL	15	18.8 ± 24.0[b]	14	32.1 ± 17.0	15	46.3 ± 26.1[b]	.01[b]	14	7.6 ± 15.7	12	7.8 ± 21.3	15	6.7 ± 17.8	.98	14	26.8 ± 25.4[b]	12	38.5 ± 24.5	15	52.9 ± 18.3[b]	.01[b]
Marx	15	–3.1 ± 7.0	14	–3.5 ± 4.5	15	–0.5 ± 3.2	.23	14	–0.6 ± 5.1	12	–0.1 ± 4.1	15	–0.1 ± 2.7	.85	14	–3.9 ± 3.2	12	–3.2 ± 5.3	15	–0.6 ± 3.2	.07
IKDC	15	25.5 ± 21.1	14	31.2 ± 12.0	15	36.0 ± 24.8	.37	14	9.5 ± 19.1	12	2.8 ± 12.2	15	2.2 ± 12.2	.36	14	36.4 ± 16.9	12	34.2 ± 14.7	15	38.2 ± 17.0	.82

[a]Scores are presented as mean ± SD. ADL, Activities of Daily Living; IKDC, International Knee Documentation Committee score; KOOS, Knee injury and Osteoarthritis Outcome Score; Marx, Marx Activity Rating Scale; PRO, patient-reported outcome; QoL, Quality of Life.
[b]$P < .05$.